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(54) **REDUNDANT ETHERNET AUTOMATIC PROTECTION SWITCHING ACCESS TO VIRTUAL PRIVATE LAN SERVICES**

(71) Applicant: **Extreme Networks, Inc.**, San Jose, CA (US)

(72) Inventors: **Olen L. Stokes**, Cary, NC (US); **Sunil P. Shah**, San Jose, CA (US); **Arnel Lim**, San Jose, CA (US)

(73) Assignee: **Extreme Networks, Inc.**, San Jose, CA (US)

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***H04L 12/42*** (2006.01)
(Continued)

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(Continued)

(58) **Field of Classification Search**

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See application file for complete search history.

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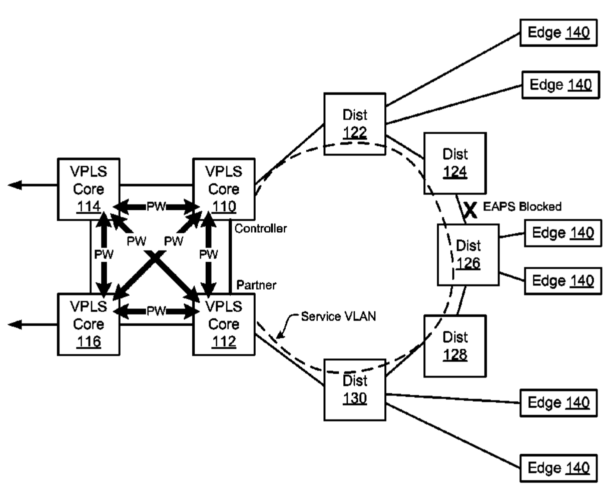
*Primary Examiner* — Feben M Haile

(74) *Attorney, Agent, or Firm* — Ropes & Gray LLP

(57) **ABSTRACT**

Embodiments disclosed herein provide redundant connectivity between an Ethernet Automatic Protection Switching (EAPS) access network and a Virtual Private LAN Service (VPLS) network. A first VPLS node is provided to function as an EAPS controller node. A second VPLS node is provided to function as an EAPS partner node. The first and second VPLS nodes are linked by a pseudowire and an EAPS shared-link. Additional EAPS nodes are also provided. The additional EAPS nodes are linked to each other and one of the additional EAPS nodes is designated as a master node. Links are also established between the VPLS nodes and the EAPS nodes such that one or more EAPS rings are formed. Each EAPS ring includes the shared-link between the first and second VPLS nodes. The EAPS rings are monitored to detect link failures. When a failure of the pseudowire shared-link between the first and second VPLS nodes is detected, all pseudowire links associated with the first VPLS node are disabled if any of the EAPS nodes has a path to both of the VPLS nodes. Otherwise, the existing pseudowire links associated with the first VPLS node are maintained.

**19 Claims, 8 Drawing Sheets**



(51) **Int. Cl.**

| | |
|---|---|
| ***H04L 12/46*** | (2006.01) |
| ***H04L 12/24*** | (2006.01) |
| ***H04L 12/26*** | (2006.01) |
| ***H04L 12/701*** | (2013.01) |
| ***H04L 12/707*** | (2013.01) |
| ***H04L 12/703*** | (2013.01) |

(52) **U.S. Cl.**

CPC .......... ***H04L 41/06*** (2013.01); ***H04L 41/0659*** (2013.01); ***H04L 43/0817*** (2013.01); ***H04L 45/00*** (2013.01); ***H04L 45/22*** (2013.01); ***H04L 45/28*** (2013.01)

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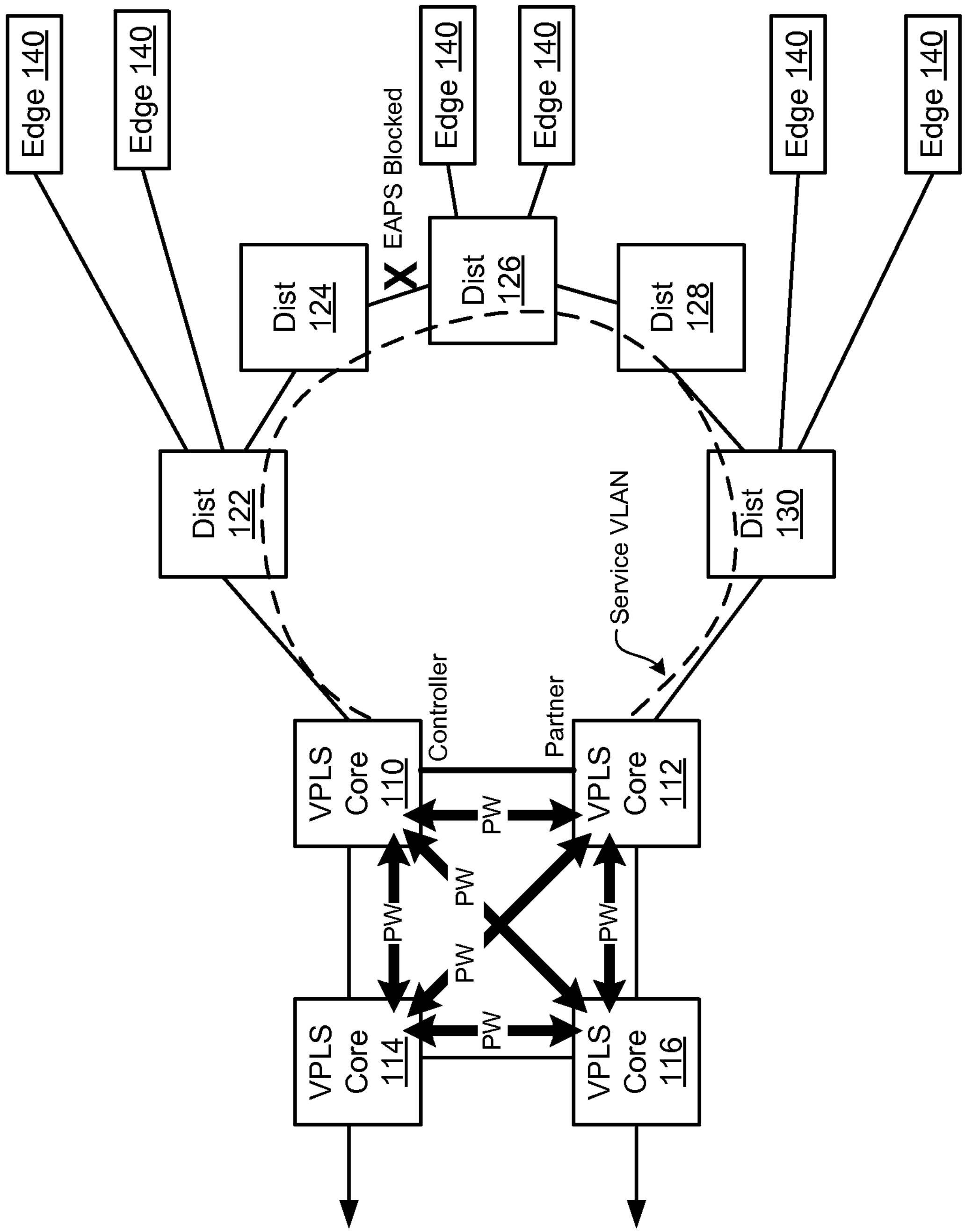
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Edge 140
Edge 140
Edge 140
Edge 140
Edge 140
EAPS Blocked
Dist 124
Dist 126
Dist 128
Dist 122
Dist 130
Service VLAN
Controller
Partner
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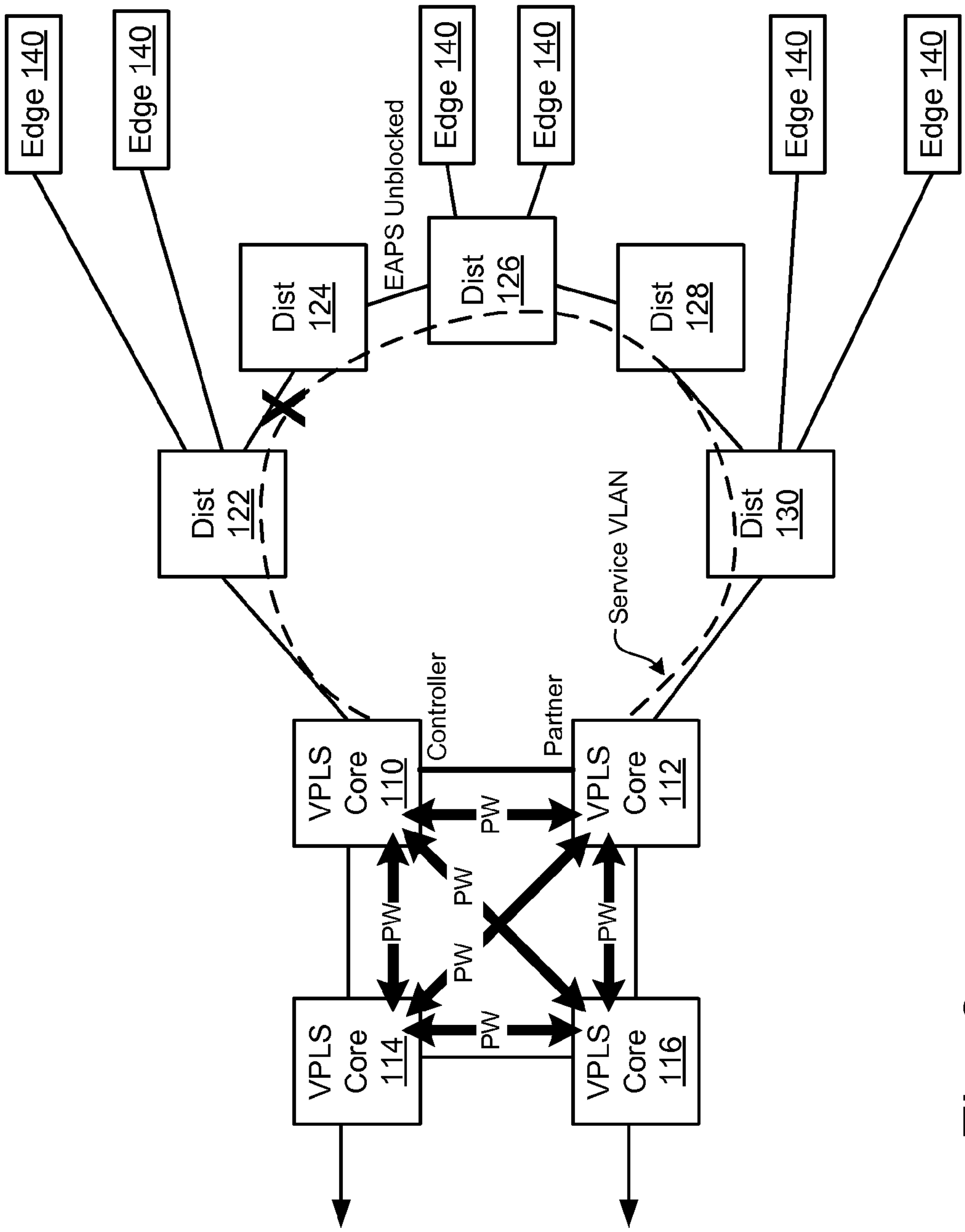
VPLS Core 112
VPLS Core 114
VPLS Core 116
PW
PW
PW
PW
PW
PW

Fig. 1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Edge 140
Edge 140
Edge 140
Edge 140
Edge 140
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Dist 124
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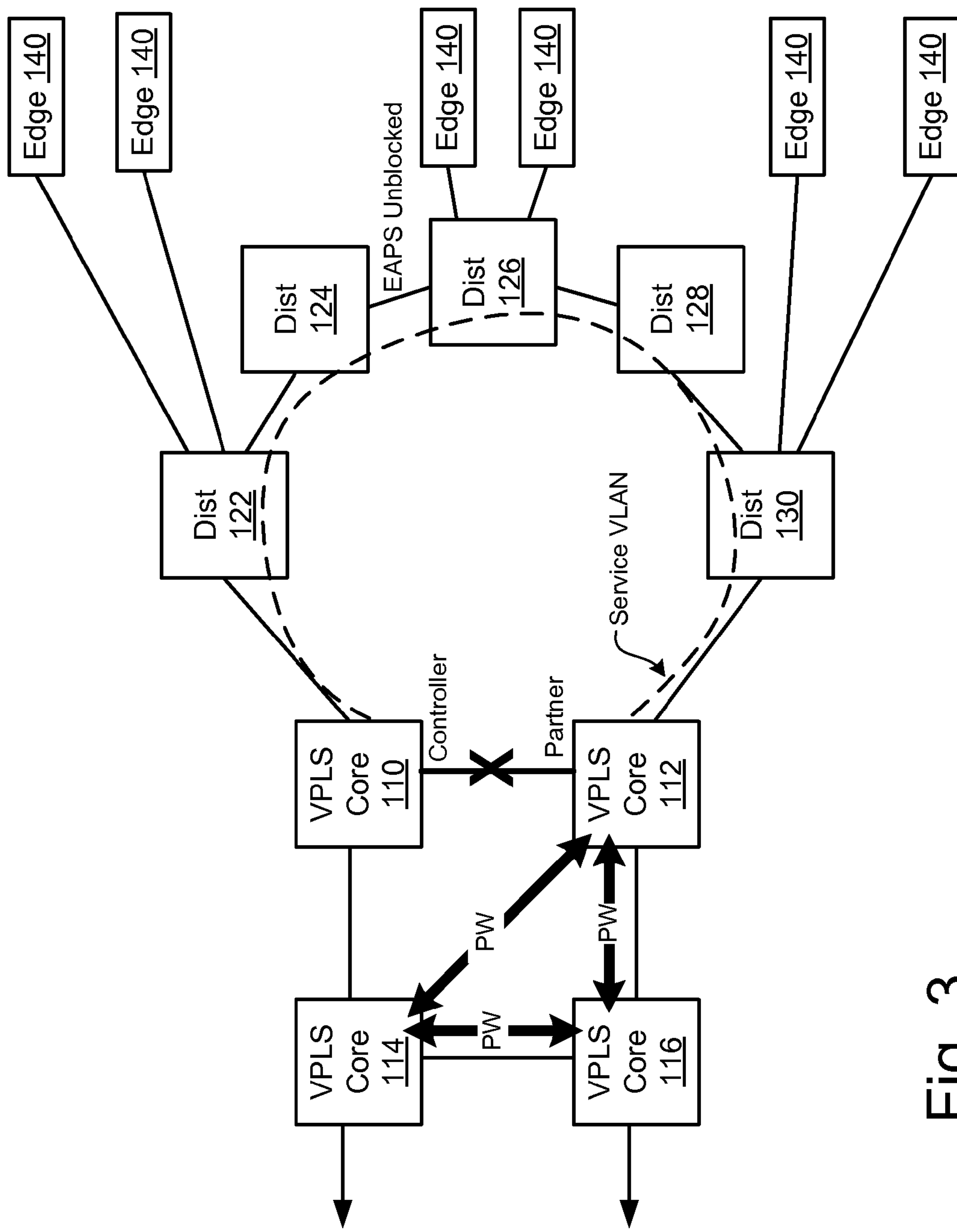
Dist 128
Dist 122
Dist 130
Service VLAN
Controller
Partner
VPLS Core 110
VPLS Core 112
VPLS Core 114
VPLS Core 116
PW
PW
PW
PW
PW
PW

Fig. 2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Edge 140
Edge 140
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Edge 140
EAPS Unblocked
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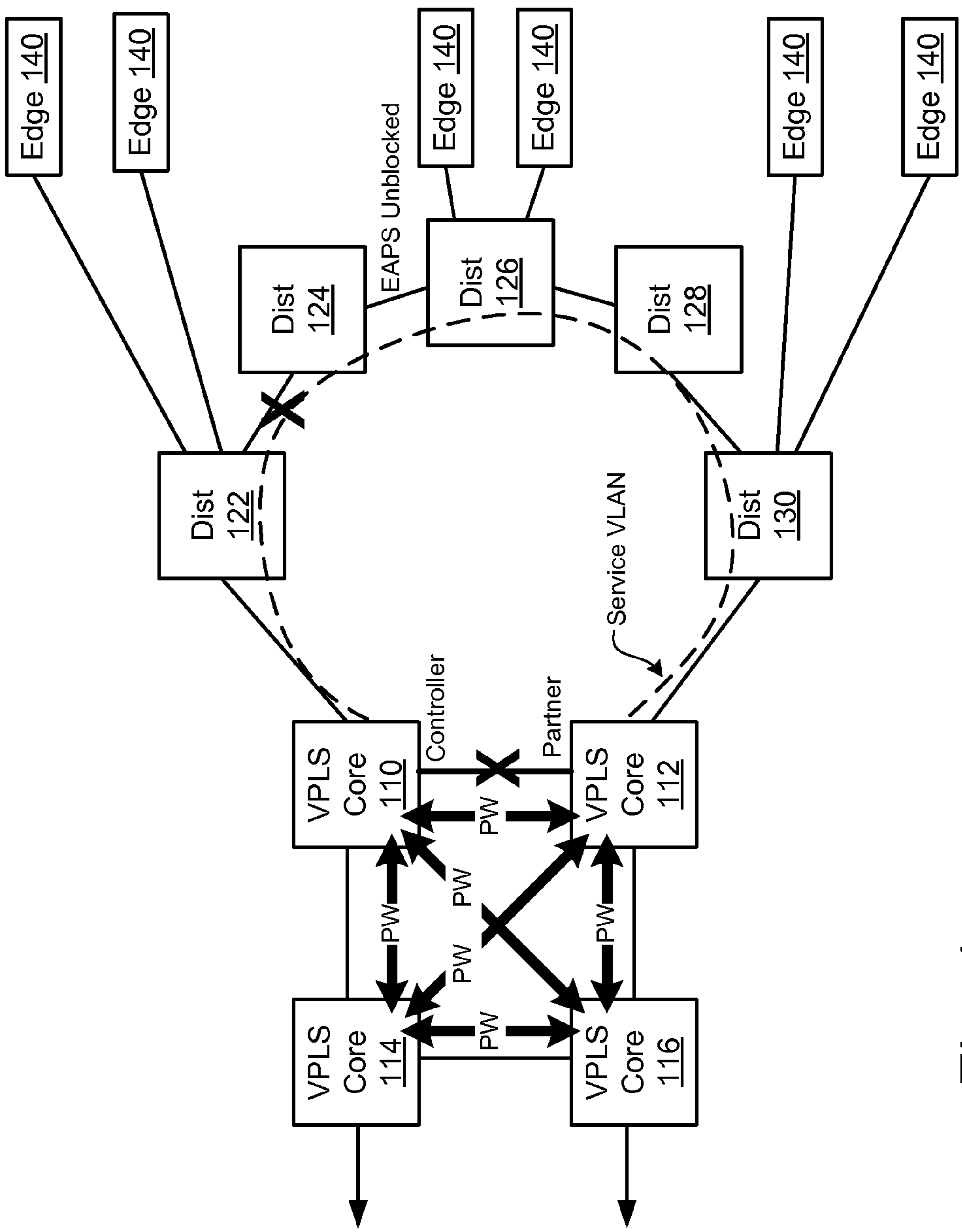
Dist 126
Dist 128
Dist 122
Dist 130
Service VLAN
Controller
Partner
VPLS Core 110
VPLS Core 112
VPLS Core 114
VPLS Core 116
PW
PW
PW

Fig. 3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Edge 140
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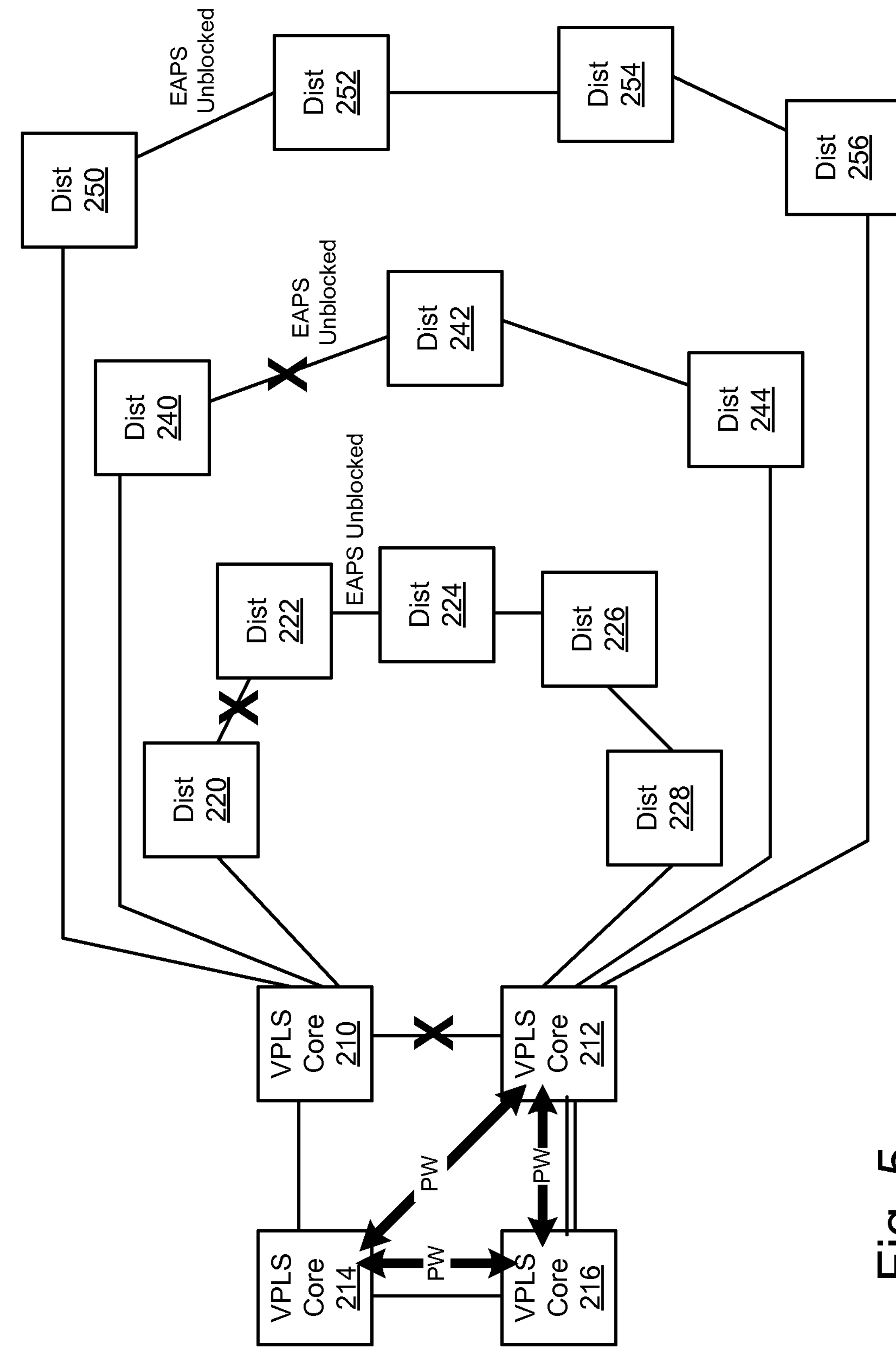
EAPS Unblocked
Dist 124
Dist 126
Dist 128
Dist 122
Dist 130
Service VLAN
Controller
Partner
VPLS Core 110
VPLS Core 112
VPLS Core 114
VPLS Core 116
PW
PW
PW
PW
PW
PW

Fig. 4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Dist 250
Dist 252
Dist 254
Dist 256
EAPS Unblocked
Dist 240
Dist 242
Dist 244
EAPS Unblocked
Dist 220
Dist 222
Dist 224
Dist 226
Dist 228
VPLS Core 210
VPLS Core 212
VPLS Core 214
VPLS Core 216
PW
PW
PW

Fig. 5

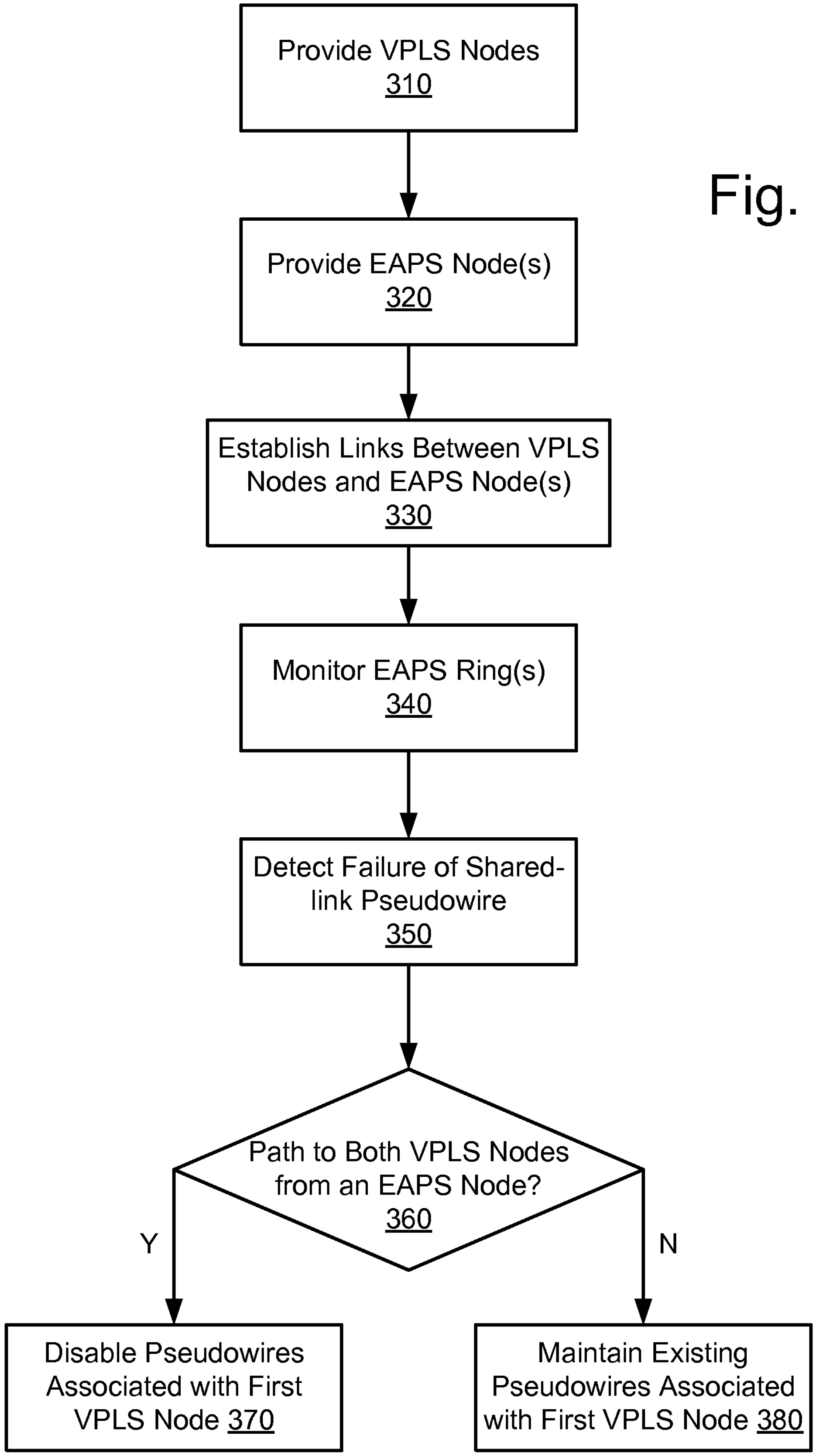
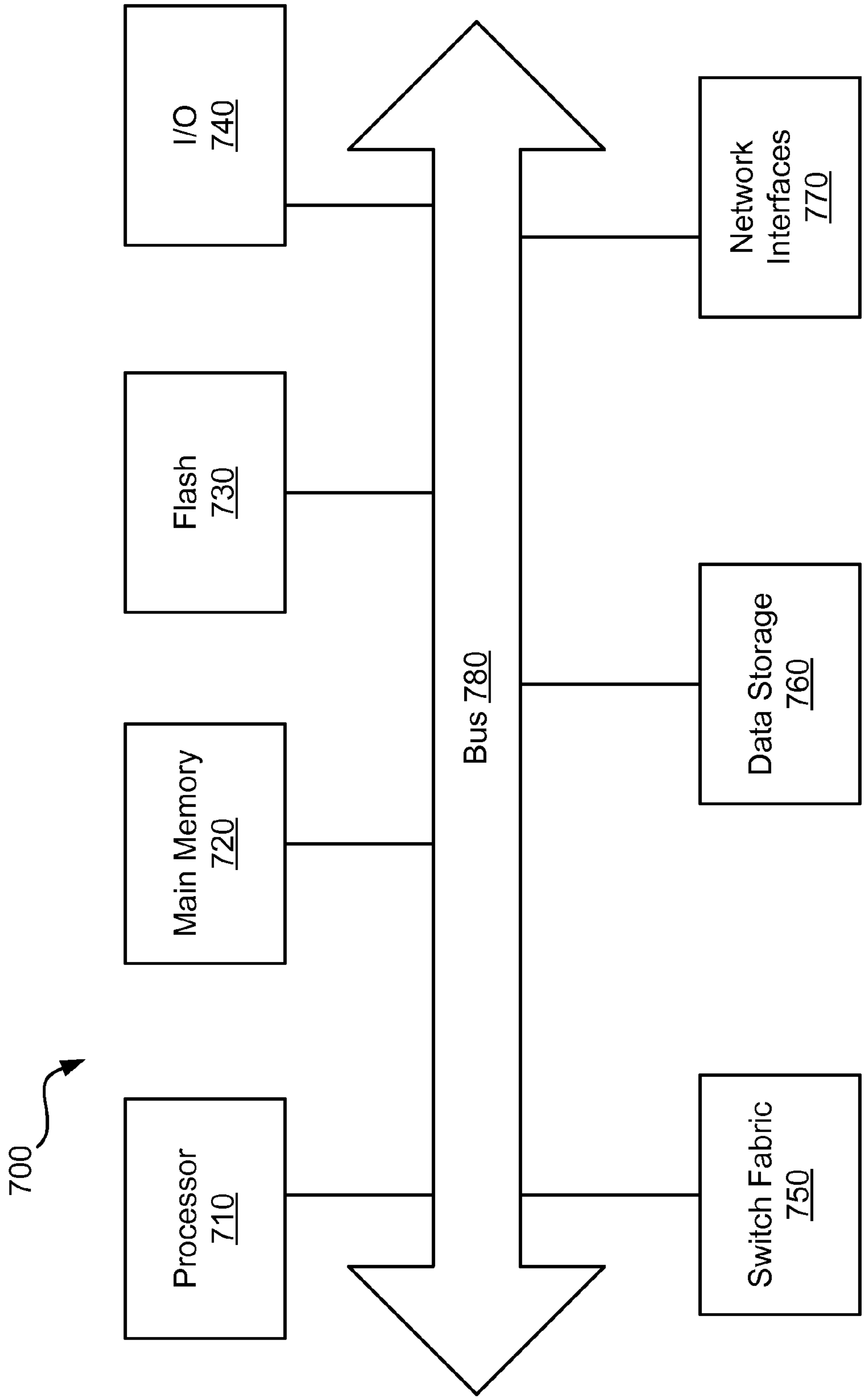

Provide VPLS Nodes 310
Provide EAPS Node(s) 320
Establish Links Between VPLS Nodes and EAPS Node(s) 330
Monitor EAPS Ring(s) 340
Detect Failure of Shared-link Pseudowire 350
Path to Both VPLS Nodes from an EAPS Node? 360
Y
N
Disable Pseudowires Associated with First VPLS Node 370
Maintain Existing Pseudowires Associated with First VPLS Node 380

Fig. 6


700
Processor
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Main Memory
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Flash
730
I/O
740
Bus 780
Switch Fabric
750
Data Storage
760
Network
Interfaces
770

Fig. 7

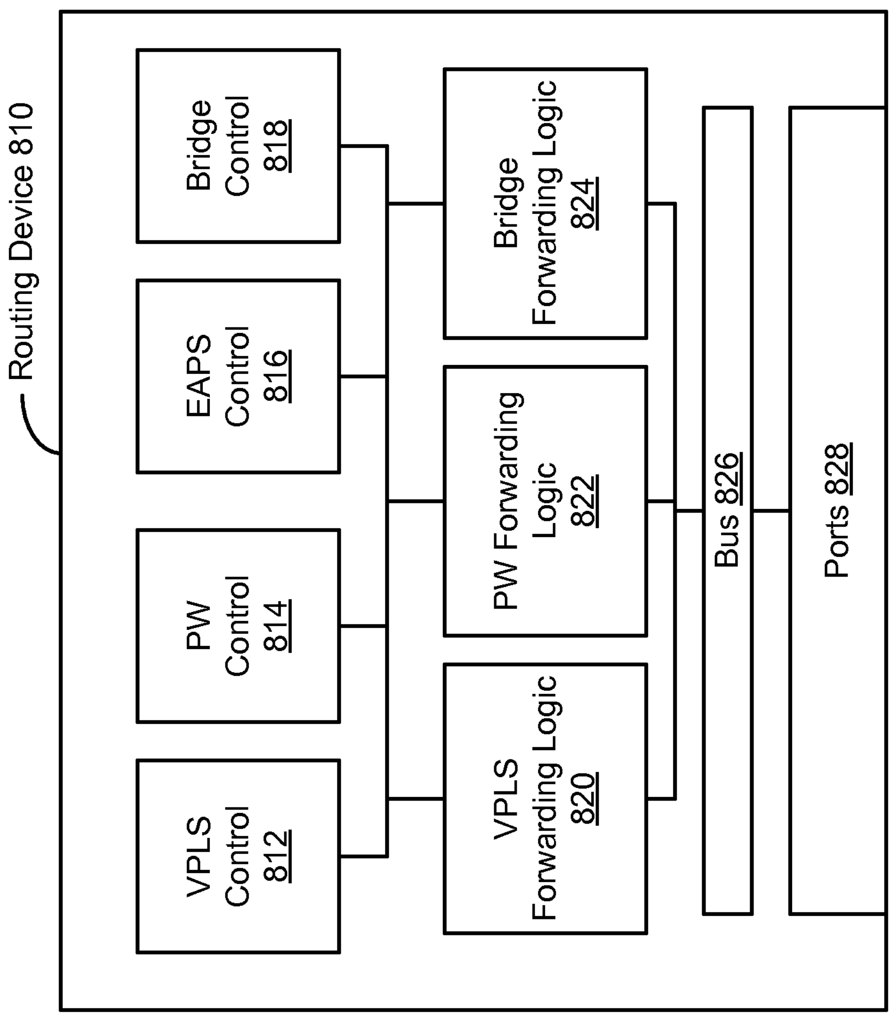
Routing Device 810
VPLS Control 812
PW Control 814
EAPS Control 816
Bridge Control 818
VPLS Forwarding Logic 820
PW Forwarding Logic 822
Bridge Forwarding Logic 824
Bus 826
Ports 828

Fig. 8

# REDUNDANT ETHERNET AUTOMATIC PROTECTION SWITCHING ACCESS TO VIRTUAL PRIVATE LAN SERVICES

## CLAIM OF PRIORITY

The present patent application is a continuation of and claims the benefit of the earlier filing date of non-provisional U.S. patent application Ser. No. 13/165,534, filed on Jun. 21, 2011 and issued as U.S. Pat. No. 8,797,849 on Aug. 5, 2014, entitled "REDUNDANT ETHERNET AUTOMATIC PROTECTION SWITCHING ACCESS TO VIRTUAL PRIVATE LAN SERVICES," which is a continuation of and claims the benefit of the earlier filing date of non-provisional U.S. patent application Ser. No. 12/101,603, filed on Apr. 11, 2008, and issued as U.S. Pat. No. 7,990,850 on Aug. 2, 2011, also entitled "REDUNDANT ETHERNET AUTOMATIC PROTECTION SWITCHING ACCESS TO VIRTUAL PRIVATE LAN SERVICES."

## FIELD

Embodiments of the invention relate to computer networking, and more particularly to redundantly connecting a VPLS network with an EAPS network.

## BACKGROUND

Computer networks are becoming increasingly important for businesses and communities. Cost efficiency, network capacity, scalability and flexibility are all important considerations in building and maintaining various networks. With a wide variety of services, protocols and technologies, it can be difficult to integrate and/or provide connectivity between different types of networks.

Virtual Private LAN Service (VPLS) is a way to provide Ethernet based multipoint to multipoint communication over IP/MPLS networks. VPLS allows geographically dispersed sites to share an Ethernet broadcast domain by connecting sites through pseudowires (PWs).

Ethernet Automatic Protection Switching (EAPS), offered by Extreme Networks of Santa Clara, Calif., is a solution for fault-tolerant networks. EAPS provides for a loop-free operation and a sub-second ring recovery. EAPS version 2 (EAPSv2) is configured and enabled to avoid the potential of super loops in environments where multiple EAPS domains share a common link. EAPSv2 functions use the concept of a "controller" and a "partner" mechanism. Shared port status is verified using health protocol data units (PDUs) exchanged by controller and partner. When a shared-link goes down, the configured controller will open only one segment port for each of the protected VLANs, keeping all other segment ports in a blocking state.

The Internet Engineering Task Force (IETF) RFC 4762, entitled "Virtual Private LAN Service (VPLS) Using Label Distribution Protocol (LDP) Signaling" proposes the use of redundant pseudowires (PWs) to attach to a VPLS core network. However, this technique is applicable only where a single attachment node is necessary. The IETF draft entitled "VPLS Interoperability with CE Bridges" also discusses redundant access to VPLS core networks. However, this technique does not address ring-based access networks and it utilizes only a single active attachment to a VPLS network. Likewise, the IETF draft entitled "Pseudowire (PW) Redundancy" discusses redundant access to VPLS core networks, but fails to address ring-based access networks and only utilizes a single active attachment to a VPLS core network.

## SUMMARY OF THE INVENTION

Embodiments disclosed herein provide redundant connectivity between an Ethernet Automatic Protection Switching (EAPS) access network and a Virtual Private LAN Service (VPLS) network. A first VPLS node is provided to function as an EAPS controller node. A second VPLS node is provided to function as an EAPS partner node. The first and second VPLS nodes are linked by a pseudowire. This pseudowire is normally transmitted across an EAPS shared-link. Additional EAPS nodes are also provided. The additional EAPS nodes are linked to each other and one of the additional EAPS nodes is designated as a master node. Links are also established between the VPLS nodes and the EAPS nodes such that one or more EAPS rings are formed. Each EAPS ring includes the shared-link between the first and second VPLS nodes. The EAPS rings are monitored to detect link failures. When a failure of the shared-link between the first and second VPLS nodes is detected, all pseudowire links associated with the first VPLS node are disabled if any of the EAPS nodes has a path to both of the VPLS nodes. Otherwise, the existing pseudowire links associated with the first VPLS node are maintained.

## BRIEF DESCRIPTION OF THE DRAWINGS

The following description includes discussion of figures having illustrations given by way of example of implementations of embodiments of the invention. The drawings should be understood by way of example, and not by way of limitation. As used herein, references to one or more "embodiments" are to be understood as describing a particular feature, structure, or characteristic included in at least one implementation of the invention. Thus, phrases such as "in one embodiment" or "in an alternate embodiment" appearing herein describe various embodiments and implementations of the invention, and do not necessarily all refer to the same embodiment. However, they are also not necessarily mutually exclusive.

FIG. **1** is a block diagram illustrating a VPLS-EAPS configuration according to various embodiments.

FIG. **2** is a block diagram illustrating a VPLS-EAPS configuration according to various embodiments.

FIG. **3** is a block diagram illustrating a VPLS-EAPS configuration according to various embodiments.

FIG. **4** is a block diagram illustrating a VPLS-EAPS configuration according to various embodiments.

FIG. **5** is a block diagram illustrating a VPLS-EAPS configuration according to various embodiments.

FIG. **6** is a flow diagram illustrating a process for redundant connectivity between a VPLS network and an EAPS network according to various embodiments.

FIG. **7** is a block diagram illustrating a suitable computing environment for practicing various embodiments described herein.

FIG. **8** is a block diagram illustrating a routing device according to various embodiments.

## DETAILED DESCRIPTION

As provided herein, methods, apparatuses, and systems enable redundant connectivity between a Virtual Private LAN Service (VPLS) network and an Ethernet Automatic Protection Switching (EAPS) network. More particularly, multiple active attachments to a VPLS network are provided in various embodiments.

FIG. **1** is a block diagram illustrating a VPLS-EAPS configuration according to various embodiments. As used herein, a VPLS-EAPS configuration involves multiple attachment points between a VPLS network and an EAPS network, the attachments normally active. As shown, VPLS core nodes **110**, **112**, **114** and **116** are linked via pseudowires. As used herein, a link refers to any line or channel over which data is transmitted. A pseudowire, as used herein, refers to a mechanism for emulating various networking or telecommunications services across packet-switched networks, such as those mechanisms that use Ethernet, Internet Protocol (IP), Label Switched Paths (LSPs), Multi-protocol Label Switching (MPLS) and/or the like. Emulated services can include T1 leased line, frame relay, Ethernet, Asynchronous Transfer Mode (ATM), time-division multiplexing (TDM), or Synchronous Optical Networking (SONET)/Synchronous Digital Hierarchy (SDH). As discussed in RFC 3985 entitled "Pseudo Wire Emulation Edge-to-Edge [PWE3] Architecture," a pseudowire delivers only the functionality necessary to emulate a wire with some required degree of fidelity for some specific service definition.

As shown in FIG. **1**, VPLS core nodes **110** and **112** are attached to the EAPS access ring. Rather than having core node **110** or **112** function as the EAPS master node, distribution node **124** is designated as the master node. When a network failure is detected on the ring, the master node in an EAPS system receives control messages over the control VLAN, the control messages indicating the network failure. During normal operation, the master node blocks the protected data VLAN traffic from traversing its secondary port. During a network failure, the master node unblocks its secondary port and routes the protected data VLAN traffic through its secondary port. The secondary port is re-blocked once the failure has been fixed. In various embodiments, any node in the EAPS ring that is not a VPLS node can be designated as the EAPS master node. In various embodiments, the VPLS core nodes attached to the EAPS ring function as EAPS controller and partner nodes, respectively. In FIG. **1**, core node **110** functions as the controller node while core node **112** functions as the partner node. The EAPS controller node (e.g., core node **110**) includes a controller state machine, which keeps track of whether EAPS nodes on the ring have access to both attached VPLS nodes (e.g., core nodes **110** and **112**).

In various embodiments, when a VPLS customer VLAN (or VMAN) is attached to an EAPS ring, as shown in FIG. **1**, the EAPS ring segment between core nodes **110** and **112** is removed in favor of a pseudowire connection between core nodes **110** and **112**. The term "shared-link," as used herein, refers to a special EAPS link that is typically shared among multiple EAPS rings. While a shared-link is often shared among multiple EAPS rings, a shared-link can also be maintained for a single EAPS ring. In addition to facilitating port management among multiple EAPS rings, functions and/or mechanisms associated with the shared-link (e.g., controller node state machine, etc.) may be used to assist in managing communication between EAPS and VPLS. The EAPS master node (e.g., node **124**) does not necessarily have or receive any information regarding the connection change between core nodes **110** and **112**. However, the EAPS functionality on core nodes **110** and **112** do have information regarding the connection change given that the connection change requires configuring an EAPS-protected VLAN with only one port on the ring. It should be noted that this configuration does not change the EAPS control VLAN—the EAPS ring is still complete and the EAPS master node (e.g., node **124**) still blocks a port on the customer access VLAN when the ring is intact.

FIG. **2** shows an example of a link failure, in this case between nodes **122** and **124**. From a connectivity perspective, various embodiments of the VPLS-EAPS configuration appropriately handle access ring failures like the link failure shown in FIG. **2**. When the EAPS master node (e.g., node **124**) detects a topology change (e.g., due to a link failure notification from a node on the ring, a hello timeout, etc.), the master node unblocks its secondary port on the protected VLAN. The only difference in FIG. **2** (as compared to FIG. **1**) is that the link failure and subsequent unblocking of the master node's secondary port causes node **124** to now connect to the VPLS network via core node **112** instead of via core node **110**. Thus, connectivity is recovered.

The connectivity recovery scenario changes when the shared-link between core nodes **110** and **112** fails. As illustrated in FIG. **3**, when the shared-link fails, the EAPS master node (e.g., node **124**) again unblocks its secondary port (as it does whenever there is a failure on the access ring). However, when this occurs, both VPLS core nodes (i.e., nodes **110** and **112**) might receive a copy of any traffic that is not destined for a node on the EAPS access ring. For example, if the shared-link between core nodes **110** and **112** failed and distribution node **126** was trying to send a packet to VPLS core node **116**, core nodes **110** and **112** might each receive a copy of the packet. This would result in duplicate packets being sent into the VPLS network. Additionally, given that the pseudowire between core nodes **110** and **112** could be reestablished using a different path (e.g., via the path from node **112** to node **116** to node **114** to node **110**), this scenario could result in a traffic loop on the EAPS access ring as well as a storm into the VPLS network. To prevent this scenario from occurring, VPLS core node **110** (functioning as the EAPS controller node) takes the action of removing and/or disabling all pseudowires associated with core node **110** when the shared-link between core nodes **110** and **112** fails. The removal of pseudowires can be seen in FIG. **3**. Once the pseudowires have been removed and/or disabled, all traffic traveling between the EAPS access network and the VPLS network passes through VPLS core node **112**. When core node **110** (i.e., the controller node) detects that the shared-link between nodes **110** and **112** is repaired, the pseudowires are reestablished.

When core node **110** removes its pseudowires, core node **110** also signals its VPLS peers (e.g., VPLS core nodes **114**, **116**, and **112**) to inform them that the pseudowires are no longer active. In some embodiments, this signaling is accomplished by completely withdrawing the pseudowires. In other embodiments, the signaling is accomplished by indicating a "standby" state for the pseudowires.

FIG. **4** shows a link failure on both the shared-link (i.e., the link between nodes **110** and **112**) and on the access ring (e.g., between nodes **122** and **124**). In a dual failure scenario such as this, VPLS core nodes **110** and **112** do not both receive a copy of ring traffic, unlike the scenario where only the shared-link fails. For example, in FIG. **4**, the only path to the VPLS network for distribution node **122** is through core node **110** in this dual failure scenario. Similarly, the only path to the VPLS network for distribution node **128** is through core node **112**. Accordingly, in a dual failure scenario where one of the failed links is the VPLS core shared-link, core node **110** maintains its pseudowires rather than removing and/or disabling the pseudowires.

FIG. **5** illustrates multiple parallel EAPS access rings attached to a VPLS core network. As shown, each of the EAPS rings is attached to both core node **210** and core node

212. Each of the EAPS rings shares the link (i.e., the shared-link) between node **210** and node **212**. Functions and/or mechanisms associated with the shared-link manage and/or maintain EAPS topology information that can be propagated to the VPLS network. Here, as long as any of the parallel EAPS rings is complete, there exists a path to both core VPLS nodes—in this case, nodes **210** and **212**. When the shared-link between nodes **210** and **212** is in a failed state (as shown), the EAPS master node on each ring unblocks its secondary port. For the two inner EAPS rings, illustrated in FIG. **5**, this causes no problems because each of these rings has an additional link failure on the ring which prevents nodes in these rings from having a path to both VPLS core nodes (i.e., nodes **210** and **212**). However, the outer ring has no other link failures. Thus, distribution nodes (e.g., **250**, **252**, **254** and **256**) on this outer ring do have a path to both VPLS nodes **210** and **212**. It should be noted that both VPLS nodes still perform L2 switching on all of the access rings. Therefore, all of the nodes on all three rings have a path to both VPLS nodes. As discussed above, a path from an EAPS ring to both core nodes on the VPLS network can cause an access ring loop and/or a VPLS storm. Thus, in embodiments having parallel EAPS rings attached to the VPLS core, the controller node (e.g., core node **210**) must disable all pseudowires associated with the controller node if and when any of the parallel EAPS rings are complete or "up" (e.g., no link failures) and the shared-link is failed. If all parallel EAPS rings are in a failed state or "down" (e.g., at least one failed link on each ring), then the controller node (e.g., node **210**) maintains all its existing pseudowires regardless of the state of the shared-link. The following table shows the recovery actions to be taken on the controller node in various embodiments:

TABLE 1

| | Core Link State | |
|---|---|---|
| Ring State | Core Link Up | Core Link Down |
| Any Parallel Ring Up | PWs Active | PWs Inactive |
| Any Parallel Ring Down | PWs Active | PWs Active |

In various embodiments, changes in topology on either the access ring(s) or the VPLS network may cause changes to the path(s) used to reach customer devices. For example, in FIG. **2**, the path that distribution node **124** would take to reach other parts of the VPLS network changes following the failure on the access ring of the link between nodes **122** and **124**. Prior to failure of that link, node **124** reached the VPLS network via core node **110**. Following the failure, node **124** accesses the VPLS network via core node **112**.

When the EAPS master node (e.g., node **124** in FIG. **1**, node **222** in FIG. **5**, etc.) detects a topology change, it sends a "flush FDB" message to its other transit nodes (i.e., the other nodes on the ring). In some embodiments, the flush message causes the ring's MAC addresses to be relearned on each node in the ring. Given that the flush message is an EAPS message that is propagated to the other nodes on the ring, the flush message is not inherently propagated over the VPLS network. Also, the attachments at the remote VPLS nodes may not be utilizing EAPS. Using the above example, VPLS node **114** (FIG. **2**) would expect to find node **124** via the pseudowire between VPLS node **114** and VPLS node **110**. However, upon the occurrence of a link failure between nodes **122** and **124**, any traffic sent from VPLS node **114** to node **124** via VPLS node **110** will not reach its destination given that VPLS node **114** is not aware of the topology change and is configured to send traffic on a path through the failed link. To overcome this problem, EAPS informs VPLS about any received EAPS "flush FDB" messages on both the controller and partner nodes (e.g., nodes **110** and **112**). The controller and partner nodes can then propagate this information so that other VPLS nodes can flush their respective forwarding databases (e.g., MAC addresses, etc.). Given that MAC addresses, for example, are learned from a particular originating node (e.g., VPLS node **116** learns the MAC address for node **128** from VPLS node **112**), both the controller and the partner node inform the other VPLS nodes of any topology changes.

FIG. **6** is a flow diagram illustrating a process for redundant connectivity between a VPLS network and an EAPS network. Two VPLS nodes are provided **310** to function as an EAPS controller node and partner node, respectively. The two VPLS nodes are linked by a pseudowire across an EAPS shared-link. Additional EAPS nodes are also provided **320**. The additional EAPS nodes are linked to each other and one of the additional EAPS nodes is designated as a master node. Links are also established between the VPLS nodes and the EAPS nodes such that one or more EAPS rings are formed **330**. Each EAPS ring includes the shared-link between the first and second VPLS nodes. The EAPS rings are monitored **340** to detect link failures. When a failure of the pseudowire shared-link between the first and second VPLS nodes is detected **350**, it is determined **360** whether any of the EAPS nodes has a path to both of the VPLS nodes. If yes, then all pseudowires associated with the controller node are disabled **370**. If no, then the existing pseudowire links associated with the first VPLS node are maintained **380**.

FIG. **7** is a block diagram illustrating a suitable computing environment for practicing various embodiments described herein. Collectively, these components are intended to represent a broad category of hardware systems, including but not limited to general purpose computer systems and specialized network switches.

Computer system **700** includes processor **710**, I/O devices **740**, main memory **720** and flash memory **730** coupled to each other via a bus **780**. Main memory **720**, which can include one or more of system memory (RAM), and nonvolatile storage devices (e.g., magnetic or optical disks), stores instructions and data for use by processor **710**. Additionally, the network interfaces **770**, data storage **760**, and switch fabric **750** are coupled to each other via a bus **780**. Data storage **760** represents the routing database (e.g., forwarding database tables, etc.) described herein as well as other storage areas such as packet buffers, etc., used by the switch fabric **750** for forwarding network packets or messages.

The various components of computer system **700** may be rearranged in various embodiments, and some embodiments may not require nor include all of the above components. Furthermore, additional components may be included in system **700**, such as additional processors (e.g., a digital signal processor), storage devices, memories, network/communication interfaces, etc.

In the illustrated embodiment of FIG. **7**, methods and apparatuses for providing redundant connectivity between an EAPS network and a VPLS network according to the present invention as discussed above may be implemented as a series of software routines run by computer system **700** of FIG. **7**. These software routines comprise a plurality or series of instructions to be executed by a processing system in a hardware system, such as processor **710**. Initially, the series of instructions are stored on a data storage device **760** (e.g., in a route manager database), memory **720** or flash **730**.

FIG. **8** illustrates the various components of a routing device that may be used in various embodiments. Routing device **810** includes a VPLS control component **812**, a pseudowire (PW) control component **814**, an EAPS control component **816**, and a Bridge control component **818**. The VPLS control component **812** facilitates establishing a complete VPLS comprised of multiple PWs. The PW control function **814** establishes the individual PWs and signals PW state information to peers. The EAPS control function **816** monitors and controls EAPS operation. The bridge control function **818** monitors and controls normal L2 bridge operation. The EAPS control function **816** provides the VPLS control **812** and/or PW control **814** functions with information about the state of the EAPS shared-link and the EAPS ring connectivity. The VPLS forwarding logic component **820**, the PW forwarding logic component **822**, and the bridge forwarding component **824** combine to forward data packets between PWs and VPLS customers. These forwarding components are coupled via bus **826**. Based on the logic of these components, traffic is routed on the routing device ports **828**. Routing device **810** is an example of a routing device that could be used for VPLS core nodes **110** and/or **112** of FIG. **2**, for example.

Various components described herein may be a means for performing the functions described herein. Each component described herein includes software, hardware, or a combination of these. The components can be implemented as software modules, hardware modules, special-purpose hardware (e.g., application specific hardware, application specific integrated circuits (ASICs), digital signal processors (DSPs), etc.), embedded controllers, hardwired circuitry, etc. Software content (e.g., data, instructions, configuration) may be provided via an article of manufacture including a computer readable medium, which provides content that represents instructions that can be executed. The content may result in a computer performing various functions/operations described herein. A computer readable medium includes any mechanism that provides (i.e., stores and/or transmits) information in a form accessible by a computing device (e.g., computer, PDA, electronic system, etc.), such as recordable/non-recordable media (e.g., read only memory (ROM), random access memory (RAM), magnetic disk storage media, optical storage media, flash memory devices, etc.). The content may be directly executable ("object" or "executable" form), source code, or the like. A computer readable medium may also include a storage or database from which content can be downloaded. A computer readable medium may also include a device or product having content stored thereon at a time of sale or delivery. Thus, delivering a device with stored content, or offering content for download over a communication medium may be understood as providing an article of manufacture with such content described herein.

Besides what is described herein, various modifications may be made to the disclosed embodiments and implementations of the invention without departing from their scope. Therefore, the illustrations and examples herein should be construed in an illustrative, and not a restrictive sense. The scope of the invention should be measured solely by reference to the claims that follow.

What is claimed is:

**1**. A method for providing redundant connectivity between an Ethernet Automatic Protection Switching (EAPS) access network and a Virtual Private LAN Service (VPLS) network, the method comprising:

providing first and second VPLS nodes from a plurality of VPLS nodes, the plurality of VPLS nodes linked with each other by pseudowire links;

establishing an EAPS ring linking the plurality of EAPS nodes with the first and second VPLS nodes, a segment of the EAPS ring coupling the first VPLS node with the second VPLS node to form an EAPS shared link between the EAPS access network and the VPLS network, the EAPS shared-link facilitating communication between the EAPS access network and the VPLS network;

tracking whether each of the plurality of EAPS nodes has access to the first and second VPLS nodes;

detecting a network failure of the EAPS shared-link between the first and second VPLS nodes;

disabling, in response to detecting the network failure of the EAPS shared-link, all pseudowire links associated with the first VPLS node when any of the plurality of EAPS nodes has a path to both the first and second VPLS nodes,

communicating an indication of the disabled pseudowire links to the plurality of VPLS nodes linked with the first VPLS node; and

reestablishing pseudowire links between the VPLS nodes when the first VPLS node detects that the EAPS shared-link between the VPLS nodes is repaired.

**2**. The method of claim **1**, wherein the first VPLS node to function as an EAPS controller node, and wherein the second VPLS node to function as an EAPS partner node.

**3**. The method of claim **1** further comprises maintaining, in response to detecting the network failure of the EAPS shared-link, existing pseudowire links associated with the first VPLS node when any of the plurality of EAPS nodes lacks a path to both the first and second VPLS nodes.

**4**. The method of claim **1** further comprises:

monitoring the EAPS ring; and

flushing forwarding database addresses on the plurality of VPLS nodes in response to detecting a network failure on the monitored EAPS ring.

**5**. The method of claim **1**, wherein one of the pluralities of EAPS nodes is designated as a master node, the master node to receive a control message indicating a network failure in the EAPS ring, including the network failure of the EAPS shared-link.

**6**. The method of claim **5** further comprises:

blocking a secondary port of the master node during normal operation; and

unblocking the secondary port of the master node in response to receiving the control message indicating the network failure in the EAPS ring.

**7**. The method of claim **1**, wherein the EAPS access network comprises multiple EAPS rings, and wherein the EAPS shared link is shared among the multiple EAPS rings.

**8**. The method of claim **7**, wherein the first VPLS node is operable to disable all pseudowire links associated with the first VPLS node when the EAPS shared-link fails and any of the multiple parallel EAPS rings is complete.

**9**. The method of claim **8**, wherein the first VPLS node is operable to maintain all existing pseudowire links when all of the multiple parallel EAPS rings fail whether or not the EAPS shared-link fails.

**10**. A method for providing redundant connectivity between an Ethernet Automatic Protection Switching (EAPS) access network and a Virtual Private LAN Service (VPLS) network, the method comprising:

providing first and second VPLS nodes from a plurality of VPLS nodes, the plurality of VPLS nodes linked with each other by pseudowire links;

establishing an EAPS ring linking the plurality of EAPS nodes with the first and second VPLS nodes, a segment of the EAPS ring coupling the first VPLS node with the second VPLS node to form an EAPS shared link between the EAPS access network and the VPLS network, the EAPS shared-link facilitating communication between the EAPS access network and the VPLS network;

tracking whether each of the plurality of EAPS nodes has access to the first and second VPLS nodes;

detecting a dual network failure of the EAPS ring and a failed EAPS shared-link between the first and second VPLS nodes, wherein none of the plurality of EAPS nodes has a path to both the first and second VPLS nodes;

maintaining, in response to detecting the dual network failure, all pseudowire links associated with the first VPLS node;

detecting a network failure of only the EAPS shared-link between the first and second VPLS nodes, wherein any of the plurality of EAPS nodes has a path to both the first and second VPLS nodes; and

disabling, in response to detecting the network failure of only the EAPS shared-link, all pseudowire links associated with the first VPLS node.

**11**. The method of claim **10**, wherein the first VPLS node to function as an EAPS controller node, and wherein the second VPLS node to function as an EAPS partner node.

**12**. A method for providing redundant connectivity between an Ethernet Automatic Protection Switching (EAPS) access network and a Virtual Private LAN Service (VPLS) network, the method comprising:

providing first and second VPLS nodes from a plurality of VPLS nodes, the plurality of VPLS nodes linked with each other by pseudowire links;

establishing multiple parallel EAPS rings linking a plurality of EAPS nodes with the first and second VPLS nodes, a segment of the multiple parallel EAPS rings coupling the first VPLS node with the second VPLS node to form an EAPS shared link between the EAPS access network and the VPLS network, wherein the EAPS shared-link is shared among the multiple parallel EAPS rings and facilitates communication between the EAPS access network and the VPLS network;

tracking whether each of the plurality of EAPS nodes has access to the first and second VPLS nodes;

disabling all pseudowire links associated with the first VPLS node when the EAPS shared-link fails and when any of the multiple parallel EAPS rings is complete; and

maintaining all existing pseudowire links when all of the multiple parallel EAPS rings fail.

**13**. The method of claim **12**, wherein the first VPLS node is to function as an EAPS controller node and wherein the second VPLS node is to function as an EAPS partner node.

**14**. A first routing device comprising:

a first forwarding logic component having a processor to direct traffic on a Virtual Private LAN Service (VPLS) network including a plurality of VPLS nodes;

a second forwarding logic component having a processor to direct traffic on an Ethernet Automatic Protection Switching (EAPS) ring including a plurality of EAPS nodes;

an EAPS control module having a processor to operate the first routing device having a controller state machine to track whether each of the plurality of EAPS nodes has access to the first routing device and a second routing device in the VPLS network;

ports to connect the first routing device to the second routing device, the second routing device also having a forwarding logic component having a processor to direct traffic on the VPLS network and the EAPS ring, wherein the connection between the first routing device and the second routing device forms an EAPS shared-link;

a pseudowire forwarding logic component having a processor to, responsive to a network failure at the EAPS shared-link, during which network failure any of the plurality of EAPS nodes on the EAPS ring has access to both the first and the second routing devices as determined by the controller state machine, disable all pseudowire links associated with the first routing device; and

the processor of the first forwarding logic component further includes logic to notify the plurality of VPLS nodes to flush forwarding database addresses in response to receiving information that any of the plurality of nodes of the EAPS ring has received a message to flush forwarding databases in response to a detected network failure in the EAPS ring.

**15**. The first routing device of claim **14** wherein one of the plurality of EAPS nodes having access to the first routing device and the second routing device is a master EAPS node having a processor logic unit to unblock a secondary port of the EAPS master node in response to detecting a network failure in the EAPS ring, including the network failure at the EAPS shared-link between the first and second routing devices in the VPLS network.

**16**. The first routing device of claim **14**, wherein the processor of the pseudowire forwarding logic component is further operable to maintain existing pseudowire links associated with the first and second routing devices in the VPLS network regardless of whether any network failure is detected in the EAPS ring at the EAPS shared-link.

**17**. The first routing device of claim **14**, wherein the EAPS access network comprises multiple EAPS rings, and wherein the shared link is shared among the multiple EAPS rings.

**18**. The first routing device of claim **15**, wherein the master EAPS node is to receive a control message indicating the network failure in the EAPS ring.

**19**. A first routing device comprising:

a first forwarding logic component having a processor to direct traffic on a Virtual Private LAN Service (VPLS) network including a plurality of VPLS nodes;

a second forwarding logic component having a processor to direct traffic on an Ethernet Automatic Protection Switching (EAPS) ring including a plurality of EAPS nodes;

an EAPS control module having a processor to operate the first routing device having a controller state machine to track whether each of the plurality of EAPS nodes has access to the first routing device and a second routing device in the VPLS network;

ports to connect the first routing device to the second routing device, the second routing device also having a forwarding logic component having a processor to direct traffic on the VPLS network and the EAPS ring, wherein the connection between the first routing device and the second routing device forms an EAPS shared-link;

a pseudowire forwarding logic component having a processor to, responsive to detecting a dual network failure of a failed EAPS ring and a failed EAPS shared-link between the first and second routing devices, during which dual network failure none of the plurality of EAPS nodes has a path to both the first and second routing devices, maintain all pseudowire links associated with the first routing device; and

the processor of the pseudowire forwarding logic component is to, responsive to detecting a failure of only the EAPS shared-link between the first and second routing devices, disable all pseudowire links associated with the first VPLS node when any of the plurality of EAPS nodes has a path to both the first and second routing devices.

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